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POSITION-CODING PATTERN

Cross-reference to Related applications

The present application claims the benefit of
Swedish patent application No. 0201846-3, filed on 18
June 2002 and U.S. Provisional patent application No.
5   60/391922, filed on 28 June 2002, which both are hereby
incorporated by reference.

Methods, apparatuses, products and computer programs
relating to the same technical field as the present
application are furthermore disclosed in US provisional
10   patent application No. 60/323694, filed on 21 September
2001 and subject to an obligation of assignment to the
assignee of the present application.

Field of the Invention

The present invention relates to a product which on
15   a surface is provided with a first position code which
codes coordinates for a plurality of first points.

The invention also relates to a method for coding, a
coding device and a method and a device for recording
information from a surface.

20   ## Background of the Invention

It is already known that it is possible to digitize
handwriting by determining how a pen used to create the
handwriting is moved. One way of doing this is to use a
base for the handwriting provided with a position-coding
25   pattern which codes coordinates for points on the base,
and also to provide the pen with a sensor which records
the position-coding pattern locally at the tip of the pen
as the pen is moved across the base. A processing unit,
which can be placed in the pen or at a distance
30   therefrom, can then decode the recorded position-coding
pattern so that the movement of the pen across the base
can be determined as a series of coordinates.

WO 01/26032, which is assigned to the applicant of
the present application, describes a position-coding

pattern which can be used precisely for digitizing handwriting. The pattern is made up of marks, which for example can be in the form of dots. Each dot has a nominal position represented by an intersection between

5   two lines in a virtual raster, for example a square grid. Each dot codes a fixed value depending on its location in relation to the nominal position. The dots can have four possible locations, for example, one on each of the four raster lines extending from the intersection, the four

10   different locations coding four different values. The coordinates of a point are coded with the aid of a plurality of dots, for example 6*6 dots. However, each dot contributes to the coding of the coordinates of a plurality of points. If a sensor first reads 6x6 dots and

15   is thereafter moved one dot distance to the side or vertically, the sensor will read dots which code the coordinates of a new point. This type of pattern in which the position resolution is smaller than the size of the partial surface required for determining a position is in

20   the present application referred to as "floating".

     Using the position-coding pattern in the above-mentioned WO 01/26032, coordinates for a very large number of points can be coded, theoretically 4^{36} points if each point is coded with 6*6 dots. All these points can

25   be said to form an imaginary surface or form dots in a coordinate system.

     WO 01/48685, which is also assigned to the applicant of the present invention, describes how such an imaginary surface can be used for information management. More

30   specifically, different partial areas on the imaginary surface are dedicated to different types of information management. It is then possible to control how information which is recorded digitally is to be handled by providing bases with a position-coding pattern which

35   corresponds to different partial areas on the imaginary surface. For example, a first base can be provided with a position-coding pattern which means that information

which is written on the position-coding pattern and is
recorded digitally by the pen is sent to a predetermined
computer for storage in the latter. Correspondingly,
another base can be provided with a position-coding

5   pattern which means that information which is recorded
digitally with the aid of this position-coding pattern is
sent as an e-mail to an address indicated by the user on
the base.

WO 01/48685 also describes how the pen which records

10   the position-coding pattern can store different digital
templates, which define how the information from
different parts of physical bases with position-coding
patterns is to be interpreted. An e-mail template can,
for example, specify that a base with a corresponding

15   position-coding pattern has a first field which is
intended for a message, a second field which is intended
for an e mail address to be interpreted by ICR
(Intelligent Character Recognition), and a third field
which constitutes a send box which the user ticks in

20   order to initiate the sending of a recorded message.

Different bases can have fields with different
functions. The number of fields can be different on
different bases. The fields can further be located in
different places on the bases, which besides may be of

25   different sizes.

As is also described in WO 01/48685, the position-
coding pattern can be arranged differently on the
physical base. According to a first alternative, the
position-coding pattern on the base can be continuous,

30   which means that it corresponds to a continuous area of
the imaginary surface. The processing unit which is to
interpret and process the digital information recorded
from the base must then know the layout of the base, i.e.
which fields there are on the base and where these are

35   located. If many different layouts are allowed, which is
of course desirable, many different digital templates
must be stored so as to be accessible to the processing

unit. This is particularly a problem if the processing
unit has a limited storage capacity and/or if it takes a
long time to change the information once it has in fact
been stored. This may be the case, for example, if the
5   processing unit is arranged in a portable user unit, such
as the pen in WO 01/48685.

.   According to a second alternative, the position-
coding pattern on the base can correspond to a combina-
tion of a plurality of separate partial areas on the
10 imaginary surface so that the position-coding pattern on
the base will be discontinuous. In the above example the
first field can then correspond to, for instance, a first
partial area on the imaginary surface which is dedicated
to message information, the position-coding pattern in
15 the second field can correspond to a second partial area
which is dedicated to address information which is to be
processed by ICR, and the position-coding pattern in the
third field can correspond to a third partial area which
is dedicated to send boxes. In this case, the location of
20 the fields on the base is thus not related to the
location of corresponding partial areas on the imaginary
surface. In this alternative, the unit which is to
interpret and process the digital information from the
base has to store a smaller quantity of information
25 because it only needs to know the coordinates of the
different partial areas on the imaginary surface.

In certain situations, however, a continuous
position-coding pattern on the base is still to be
preferred. If the pattern is of the floating type,
30 positions will not be able to be defined in a boundary
area between two different fields in the discontinuous
position-coding pattern since the dots in the boundary
area do not code coordinates for adjacent points on the
imaginary surface. One way of solving this problem is to
35 have no position-coding pattern in the boundary area so
that points belonging to one or the other field can be
detected unambiguously. Such boundary areas without

position-coding pattern can be undesirable, especially when the product is small.

A further problem with a discontinuous position-coding pattern on the base may arise if the sensor in the pen is displaced from a pen point of the pen used to make graphical notes on the physical base. It may then happen that the pen point is placed in a first field in the discontinuous position-coding pattern, but that the sensor, owing to the displacement, records the position-coding pattern in another field on the base, which in turn may result in the pen not performing the function intended by the user.

The position-coding pattern corresponding to a digital template can be applied as it is on a base. Alternatively, different partial areas of the position-coding pattern corresponding to the digital template can be "cut out" and arranged in a different spatial arrangement on the base. The different partial areas of the digital templates correspond to different fields, which may have different functions, on the base.

The pen does not need to know the spatial arrangement of the different fields on the base in order to determine how to handle coordinates recorded from the base. However, if the movement of the pen over the base is to be displayed by an external unit, e.g. a PC, to which the coordinates are sent, the PC needs to know the spatial arrangement of the fields on the base. Unfortunately, the PC cannot determine the spatial arrangement from the coordinates sent to it from the pen.

Summary of the Invention

An object of the present invention thus is to make it possible for a user unit having a limited storage capacity to handle templates for bases with position-coding patterns.

Another object of the present invention is to provide bases with position-coding patterns, which can be read correctly using a user unit which has a displacement

between on the one hand a pen point that can be used to make marks on the base and, on the other hand, a sensor which records the position code.

Yet another object of the present invention is to enable a unit, which receives information recorded by means of a pen and a position-coding pattern on a base, to re-create the movement of the pen over the base.

One or more of these objects and other objects that appear from the above and the following description are wholly or partly achieved by a product according to claim 1, a method for coding according to claim 13, a coding device according to claim 18, a method for recording information according to claim 19, and a device for recording information according to claim 25.

More specifically, the invention concerns according to a first aspect a product, which on a surface is provided with a first position code which codes coordinates for a plurality of first points and which in at least one partial area on the surface is further provided with a second position code which codes coordinates for a plurality of second points, said partial area comprising a field which is associated with a predetermined function which is to be performed in consequence of a user unit being placed in the field.

The first position code extending over the surface enables position determination over the entire surface. It also makes it possible for a user unit to electronically record information written on the surface by means of a pen point of the user unit. The first position code can be said to correspond to the continuous position-coding pattern mentioned by way of introduction.

The second position code makes it possible to mark on the surface one or more fields so that a user unit electronically can detect that its pen point is located in a certain field on the surface and that a determined function thus is to be performed. The first and second position code may thus together create a position-coding

pattern which to some extent resembles the discontinuous position-coding pattern mentioned by way of introduction. By both the first and the second position code being located in the partial area, the problem with areas with

5   undefined coordinates in the transition to the partial area, however, is reduced. Furthermore the problem with the memory intensive storage of templates as well as the problem with the displacement of the pen point can be solved.

10   The idea behind the invention is based on use of the first position code for a first purpose and the second position code for a second purpose. Therefore it must be possible to distinguish the first and the second points from each other and to separately decode the coordinates

15   for the first and the second points.

The first points and the second points can be distinguished from each other by being points in a first and a second coordinate system respectively. Some or all of the first coordinates and the second coordinates can then

20   have the same nominal values.

The first points and the second points can alternatively be distinguished from each other by relating to different coordinate areas in one and the same coordinate system. The coordinates coded by the first position code

25   and the coordinates coded by the second position code consequently have different nominal values.

The partial area can be larger than the field. This condition may be convenient when there is a displacement between a sensor of a user unit and a point, such as a

30   pen point, of the user unit which can be used by the user to indicate positions on the product surface. Knowing the size of the displacement makes it possible for the user unit to determine the location of the pen point in the partial area, and knowing the field's extent and location

35   in the partial area makes it possible for the user unit also to determine whether the pen point is located in the field or not.

The first and the second position code can be
indicated in different ways on the product. For example,
the second position code can be spatially separated from
the first position code. If the location of the first and

5   the second position code can be determined, then the
first and the second position code can be indicated in
the partial area in an identical manner. Alternatively,
they may of course be indicated in different ways.

The coordinates of a point can be coded by means of

10   a single symbol. Alternatively, the coordinates for each
of said plurality of first points can be coded by means
of a first plurality of marks, and the coordinates for
each of said plurality of second points can be coded by
means of a second plurality of marks. Thus both the first

15   and the second position code can be of the floating type.

The first position code and the second position code
can be spatially coinciding in the partial area. At least
some of the marks in the partial area are then common to
the first and the second position code, and the first

20   position code can be coded by variation of a first
parameter of the common marks and the second position
code can be coded by variation of a second parameter of
the common marks. For example, the first position code
can be coded by the locations of the marks in relation to

25   a number of nominal points being varied, and the second
position code by the shape of the marks being varied.

By means of the second position code, one or more
function fields can, as mentioned above, be marked on the
surface provided with the first position code. This can

30   be done in a flexible way without a large number of
digital templates needing to be stored.

More specifically, the total coordinate area that
can be coded by means of the second position code can be
divided into smaller coordinate partial areas, in each of

35   which a coordinate field is defined, associated with a
predetermined function. Furthermore information about the
size of a corresponding coordinate area in the first

position code can be associated with one or more of these coordinate partial areas. Such a coordinate partial area corresponding to the second position code is then assumed, in decoding, to be associated with the coord-
5   inate area of the indicated size, corresponding to the first position code, all information recorded from the coordinate area corresponding to the first position code being processed as belonging together. In some cases, the function associated with the coordinate field can be
10   performed for all information recorded with the corre-sponding part of the first position code. The division of the total coordinate area coded by the second position code can be stored in a description in a memory of the device which is to record information from a product with
15   the first and the second position code. Since that part of the second position code which codes a certain coordinate partial area can be used to mark fields on different parts of the first position code, i.e. within completely different coordinate areas coded by the first
20   position code, the above description will require much smaller storage space than the storage space that would be required to store corresponding digital templates when using the continuous position-coding pattern described by way of introduction. This means that a large number of
25   digital templates are replaced by a single digital templ-ate which describes the division of the total coordinate area coded by the second position code.

The second position code can furthermore be used for enabling a unit, which receives information recorded by
30   means of a pen and a position-coding pattern on a base, to re-create the movement of the pen over the base.

More particularly, if the surface comprises at least two adjacent fields, wherein the first position code in said at least two adjacent fields codes coordinates
35   within at least two non-adjacent coordinate areas, the problem can be solved by letting the second position code extend over said at least two adjacent fields, so that

the position information from the second position code can be used to determine how a pen which has recorded coordinates in the non-adjacent coordinate areas by means of the first position code, was moved over the surface
5   when recording the coordinates.

Brief Description of the Drawings

The present invention will now be described by way of embodiments with reference to the accompanying drawings, in which
10   Fig. 1 shows schematically a prior-art system for information management, which system uses a coding pattern for controlling the information management,

Fig. 2 shows schematically how a first and a second position code are arranged on a sheet of paper with
15   different fields,

Fig. 3 shows schematically the second position code and a field defined by the same,

Fig. 4 illustrates schematically how the second coordinate system is divided into coordinate areas,
20   Fig. 5 illustrates schematically the terms page size and offset which are associated with coordinate areas with send box function,

Fig. 6 shows schematically how the first position code is made up,
25   Fig. 7 shows schematically how the first and the second position code are coded by means of a common coding pattern,

Fig. 8 shows schematically how the second position code is divided into cells,
30   Fig. 9 illustrates how different possible cell values are coded in the second position code,

Fig. 10 shows schematically a coding device,

Fig. 11 is a flow chart and shows an example of how coding of the first and the second position code can be
35   carried out,

Fig. 12 shows schematically a decoding device,

Fig. 13 is a flow chart and shows an example of how decoding of the first and the second position code can be carried out,

Fig. 14 shows schematically how difference groups
5   are defined for a cell in the second position code, and

Fig. 15 shows a plot of probability values.

Fig. 16 shows schematically how partial areas of a position code can be cut out from a digital template and assembled in a different spatial arrangement on a
10 surface.

Description of Embodiments

Fig. 1 shows schematically a system for information management in which the present invention can be used. The system comprises a base 1 in the form of a sheet of
15 paper, a user unit 2 and an external unit 3. The paper 1 is provided with a position-coding pattern (not shown in Fig. 1). The user unit 2 is used to write on the paper 1 using a pen point T and to simultaneously record the pen strokes in digital form by means of a sensor S which
20 images the position-coding pattern on the paper 1. The digitally recorded information can be processed in the user unit 2 and/or the external unit 3, to which it can be sent automatically or at a signal from the user.

The paper 1 shown in Fig. 1 is an example of a form
25 which can be used for graphic e-mail messages. It has three different fields 4-6, a first field 4 constituting a message field, a second field 5 constituting an address field and a third field 6 constituting a send box. The different fields are marked on the paper in a way that
30 makes the user understand which fields are which and for what they are to be used. The fields can, for example, be marked with frames and explanatory texts or symbols.

Information recorded digitally from the paper is to be processed differently by the user unit 2 depending on
35 from which field it originates. Information recorded from the message field 4 is to be processed as part of the actual graphic e-mail message. Information recorded from

the address field is to be interpreted by ICR (Intell-
igent Character Recognition) for the address to which the
e mail message is to be sent to be determined by the user
unit. Information recorded from the send box 6, however,

5   is to be interpreted as a request that the graphic e mail
message is to be sent to the address recorded from the
address field 5.

To this end, the user unit 2 must be able to
determine from which field different parts of the

10   recorded information originate. This is achieved by the
position-coding pattern on the paper comprising on the
one hand a first position code that is used to digitally
record the information written on the paper and, on the
other hand, a second position code that is used to "mark"

15   the different fields for the user unit. In this example
it is assumed that the first position code codes coordi-
nates for first points in a first coordinate system and
the second position code codes coordinates for second
points in a second coordinate system. Different functions

20   or properties can be associated with different coordinate
areas in the first and the second coordinate system.

Fig. 2 shows schematically that the first position
code 7, which is indicated by lines tilted to the right,
extends over the surface of the entire sheet of paper and

25   thus enables digital information recording over the
entire surface, while the second position code 8, which
is indicated by lines tilted to the left, extends merely
in partial areas 9' and 9" where it is used to mark
fields for the user unit 2. As is evident from Fig. 2,

30   the partial areas 9' and 9" are larger than the corre-
sponding fields 5 and 6. The purpose of this is that the
user unit 2 should be able to detect the fields even if
it has a pen point and a sensor which are offset from
each other.

35   This is illustrated in more detail in Fig. 3, which
schematically shows part of the paper 1 with the send box
6 and the partial area 9", the second position code 8

extending over the partial area 9″. Also the first
position code 7 is located in this partial area 9″, but
is not indicated in the Figure for the sake of clarity.
The size of the partial area 9″ relative to the field is
5   such that, independently of where the pen point T of the
user unit is located and independently of the rotation of
the user unit 2 about its own axis, the sensor will
always be located in the partial area 9″ and thus be able
to detect the second position code 8.

10   This is illustrated in Fig. 3 with the aid of two
different pen point positions t1 and t2 and associated
sensor positions s1 and s2. By the sensor recording the
second position code 8, the user unit can determine the
coordinates coded by the second position code 8 in the
15   field of view of the sensor S. Thus, the sensor unit 2
can determine the position of the sensor S in the partial
area 9″. Knowing the pen point displacement and the
rotation of the pen about its own axis in relation to the
position-coding pattern, the user unit 2 can further
20   calculate where the pen point T is located. If the user
unit also knows where in the partial area 9″ the field 6
is placed, it can finally determine whether the pen point
T is located in the field or not and, thus, how the
information simultaneously recorded digitally via the
25   first position code is to be processed.

In this way, the user unit can thus distinguish the
cases shown in Fig. 3 where the sensor is located in the
position S2, but the pen point is located in the position
t2, i.e. in the field 6, or in the position t3, i.e.
30   within the partial area 9″ but outside the field 6, which
means that the pen point is in the message field 4, or
finally in the position t4, i.e. outside the partial area
9″, which also indicates that the pen point is in the
message field 4.

35   In this example, the message field 4 thus is not
marked by means of the second position code 8, but the
message field constitutes the entire part of the paper 1

which is provided with the first position code 7 and
which does not consist of the address field 5 and the
send box 6. The address field 5 and the send box 6 can
further be distinguished from each other by the second
5 position code 8 in the respective partial areas 9' and 9"
of the address field 5 and the send box 6 coding coordi-
nates for points within different coordinate partial
areas in the second coordinate system.

This is illustrated in Fig. 4, which schematically
10 shows the second coordinate system with its coordinate
axes x and y. The second coordinate system is divided
into different coordinate partial areas 9 that are used
to mark fields with different functions on a surface
provided with the first position code so that a user unit
15 can detect that it is placed in such a field on the
surface. The field on the surface is defined by a coordi-
nate field centrally in each coordinate partial area. For
the sake of simplicity, only one such coordinate field is
shown in Fig. 4, viz. the coordinate field 10 in the
20 coordinate partial area 9a. In this example, the coordi-
nate field 10 is assumed to be associated with a send box
function corresponding to the send box 6 in Figs 1-3. In
Fig. 4, all coordinate partial areas 9 have the same size
and shape, but it is of course possible to choose to
25 divide the second coordinate system into coordinate part-
ial areas 9 with different sizes and different shapes.
Thus also the coordinate fields can have different sizes
and different shapes. If this is the case, the size and
shape of the coordinate fields must be associated with
30 the respective coordinate partial areas 9 so that the
user unit 2 knows which points in the second coordinate
system are included in the different coordinate fields.

The different coordinate fields in the second coor-
dinate system can further be associated with different
35 functions, which also means that corresponding fields on
the surface are associated with corresponding functions.

Each coordinate field can have one or more associated functions.

One example of a function is that the user unit 2 is to give feedback to the user when it detects that it is
5   placed in a certain field on the surface. The feedback can be given, for example, as a sound signal, a light signal or a tactile signal generated by the user unit 2.

Another example of a function that may be associated with a coordinate field is the function that the user
10 unit is to send digitally recorded information when it detects a send box, such as the send box 6 in Figs 1-3. In this example, it is the information that has been recorded from the sheet of paper 1 by means of the first position code on this sheet that is to be sent when the
15 send box 6 is detected. Then the user unit 2 must be able to determine which of the information recorded by the user unit originates from precisely the sheet of paper 1 in contrast to other sheets of paper or bases from which information may also have been recorded in the user unit.
20 More specifically, the user unit must be able to determine which of the coordinate pairs recorded by means of the first position code belong to that coordinate area in the first coordinate system which corresponds to the first position code on the sheet of paper 1. To this end,
25 a page size and an offset are associated with each of the coordinate partial areas 9 in the second coordinate system which has an associated send box function.

Fig. 5 illustrates the terms page size and offset. More specifically, Fig. 5 shows once more the sheet of
30 paper 1 in Fig. 1. The partial area 9″ is provided with a second position code which codes coordinates for points in the coordinate partial area 9a in the second coordinate system in Fig. 4. As mentioned above, the coordinate field 10 with a send box function corresponding to the
35 send box 6 is defined in the coordinate partial area 9a. With the coordinate partial area 9a are further associated two variables Xsize and Ysize which define the size

in x and y direction on that page, i.e. coordinate area
in the first coordinate system, which is associated with
the coordinate field 10 and thus with the send box 6.
Moreover, an offset indicating where on the page the
5   partial area 9a is located is associated with the
coordinate partial area 9a. The offset is indicated as a
displacement in x and y direction from the upper left
corner on the page.

     Now assume that the user unit on the sheet of paper
10   1 has detected coordinates for a first point in the first
coordinate system and a second point in the second
coordinate system. If the user unit knows the division of
the second coordinate system into coordinate partial
areas and coordinate fields, it can now determine in
15   which of the coordinate partial areas the second point is
located. With a possible knowledge of displacement
between its sensor and its pen point, the sensor unit can
further determine whether the pen point is located in a
field on the paper. If this is the case, it can identify
20   a function associated with the field. Now assume that the
user unit 2 determines that the second point corresponds
to a location of the user unit's pen point T in the send
box 6. The user unit 2 can then with the aid of the
associated page size, the offset and the coordinates for
25   the first point in the first coordinate area determine,
for instance, which coordinates are coded in the upper
left corner and the lower right corner on the paper 1.
Thus, the user unit 2 knows which parts of the informa-
tion digitally recorded in the form of coordinates
30   originate from the paper 1 and can send this information.

     The second coordinate system may contain a plurality
of different coordinate partial areas with associated
send boxes with different associated page sizes and
offsets, so that largely all conceivable pages with all
35   conceivable locations of send boxes can be provided by
the send boxes being marked with the second position
code.

As a further example of the function that can be
associated with a field, ICR interpretation may be
mentioned. The function means that what is being written
in the field is to be interpreted by ICR to a character-
5   coded format.

When the user unit detects that digitally recorded
information originates from an ICR field, it can mark
that the digitally recorded pen strokes are ICR pen
strokes. When the send box 6 is detected and the page
10   size has been determined, the user unit can compile all
ICR pen strokes coming from the page belonging to the
detected send box and interpret these by ICR. In this
manner, the user unit can determine, for example, an
address to which an e mail message is to be sent or a
15   heading or a title in a message.

It should be emphasized that fields with an asso-
ciated ICR function or feedback function can be located
optionally relative to the first position code.

A description of the second coordinate system's
20   division into coordinate partial areas 9, the coordinate
fields thereof and the information associated therewith
is in this embodiment stored in the user unit 2 so that
the user unit can perform some processing of the recorded
information without communicating with external units.

25   In the following the first and the second position
code will be described in more detail.

The first position code extends, as mentioned above,
over the entire paper 1 and is used to digitally record
the pen strokes made by the user unit on the paper 1.

30   In this example, coordinates for points in the first
coordinate system are coded by means of the first posi-
tion code in the way described in WO 01/26032 mentioned
by way of introduction. As illustrated in Fig. 6, the
position information is then recorded by means of marks
35   20, here in the form of dots. Each dot has a nominal
position 21 which is given by the intersection between
the lines 22 in a raster. The raster can be virtual but

is here for the sake of clarity indicated by dashed
lines. Each dot may be situated in one of four
predetermined locations in relation to the nominal
position, viz. on a raster line above, to the right,

5   below or to the left of the nominal position. Fig. 6
shows examples of the different locations. Depending on
the location, the dot may, for instance, code the bit
pairs (0,0; 0,1; 1,0; and 1,1). A position can, as
mentioned by way of introduction, be coded by 6*6 dots.

10   The position is obtained as a coordinate pair. With 6*6
dots, theoretically 4^{36} unique coordinate pairs can be
coded. These coordinate pairs or points can be said to
jointly form an imaginary surface or a first coordinate
system where the resolution between the points corre-

15   sponds to the distance between the dots on the paper. The
principles of the decoding from the 6*6 bit pairs to
coordinate pairs are described in detail in the above-
mentioned WO 01/26032 and will therefore not be repeated
here.

20   In the first position code, the position information
is thus coded in this example by the locations of the
dots being varied. In the second position code, the
position information is instead coded by the size of the
dots being varied. Fig. 7 shows an example of this. Each

25   dot now has, not only a location, but also a size value.
In this example, each dot has either the size value
"small" (see for instance the dot 31) or the size value
"large" (see for instance the dot 32).
       The second position code could code position infor-

30   mation with the same resolution as the first position
code if, for instance, each dot was allowed to have one
of four possible size values and 6*6 dots were allowed to
correspond to a position.
       Since, as will be evident from the following, the

35   same number of positions is not required in the second
position code, it is instead possible to let the second

position code have a lower position resolution and make
the second position code more robust.

To this end, the second position code, as schematic-
ally shown in Fig. 8, is divided into cells 40, each

5   containing four dots. The cells are usually not marked on
the base on which the position-coding pattern is located,
but are virtual cells. For the sake of clarity, however,
they are marked with dashed lines 41 in Fig. 4.

In this example, each cell contains four dots. Cells

10   with a different number of dots may, of course, be used.
Nor do the cells have to be square like in this example,
but may have other shapes, such as rectangular, triangu-
lar or hexagonal. The preferred shape can be affected by
the configuration of the raster for the dots. All cells

15   need not necessarily be of the same size, as long as it
is possible to determine their extent.

As is evident from Fig. 8, the cells do not overlap
each other, but they are fixed in relation to the first
position code, which makes it easy to determine their

20   location as soon as the first position code has been
decoded.

In this example, the coordinates for each point in
the first coordinate system are coded with 6*6 dots, as
mentioned above. Furthermore, the coding is "floating",

25   which means that each set of 6*6 dots codes coordinates
for a unique point in the first coordinate system. The
coordinates are defined for the upper left dot in each
6*6 set. This fact can be used to determine the location
of the cells for the second position code. In this

30   example, the upper left corner of each cell has in fact
an even x coordinate and an even y coordinate.

For increased robustness in coding, each cell
further contains in this example merely two large dots
and two small dots. This makes it possible to code six

35   different values for each cell, but in this example only
four of the possible combinations are used. The used
combinations and the values coded by them are shown in

Fig. 9. In the areas where the second position code is not present, the cells will only contain small dots. The absence of cells of different sizes thus indicates in this example the absence of the second position code.

5   By the cells in the second position code coding four different values, coordinates for points in the second coordinate system can be coded in the same way as coordinates for points in the first coordinate system. The principles of the above-mentioned WO 01/26032 are thus

10   applicable if the dots in the first position code are replaced by the cells in the second position code. However, in this example the coordinates for each point in the second coordinate system are allowed to be coded by 3*3 cells, which corresponds to 6*6 dots. With these

15   3*3 cells, it will be possible to code coordinates for 4^9 = 262144 unique points in the second coordinate system. These points in the second coordinate system can be said to jointly form a second imaginary surface.

       The first and the second position code are in this

20   example coded graphically by means of the dots with different locations and different sizes. These dots jointly form a position-coding pattern which can be arranged on a product, such as the paper in Fig. 1.

       When the position-coding pattern is to be arranged

25   on a product, it can be fetched in a completed state from a dedicated storage. Alternatively, the coding of the position-coding pattern can take place in a coding device, for example at a party who wants to create a page with a special layout for information management.

30   One example of a coding device is shown schematic-ally in Fig. 10. The coding device, which for instance can be realized using an ordinary personal computer, comprises a processor unit 70 which in addition to the actual processor 71 comprises a working memory 72 and a

35   program memory 73 which stores a program for providing the position-coding pattern. Moreover the coding device comprises an input means 74 which makes it possible for a

user to input information about a desired layout to the
processor. The input means 74 can be, for example, a
keypad or a mouse or an equivalent input unit which is
normally used together with a computer. To the coding
5   device there can also be connected a unit 75 which on the
basis of the digital representation of the position-cod-
ing pattern arranges the graphic position-coding pattern
on a product. The unit may consist of, for example, a
printer printing the coding pattern on a paper, or
10 alternatively, of some other kind of printing device.

Now the coding will be described with reference to
the flow chart in Fig. 11.

In a first step 80, the processor 71 in the coding
device receives an indication, inputted by the user, of
15 which coordinate area the first position code is to code.
The indication may consist of a choice among predefined
coordinate areas or of an explicit indication of an area
in the form of e.g. a coordinate pair which defines the
upper left corner of the area, and a width and a height
20 of the page. In conjunction with this step, space is
allocated in the working memory 72 for storing a digital
representation of the coding pattern. For each mark in-
cluded in the coding pattern, the processor then calcul-
ates in step 81 a value for a first parameter which in
25 this example is the location of the mark, according to a
predetermined algorithm. The above-mentioned WO 01/26032
describes how such an algorithm can be composed. The
value of the first parameter for each mark is stored in a
first matrix in the working memory 72. For instance, the
30 value may be given as a number between 0 and 3, where 0
indicates that the mark is offset to the right from its
nominal position, 1 that it is offset upwards, 2 that it
is offset to the left and 3 that it is offset downwards.

Subsequently the processor 71 receives an indication
35 of at least one partial area which is to be indicated by
means of the second position code and the location of
this partial area within the coordinate area coded by the

first position code, step 82. The indication may comprise
a choice of one or some of the coordinate areas in the
second coordinate system in Fig. 4, i.e. a choice among
predetermined coordinate partial areas. If the chosen
5   coordinate partial area is associated with a send box
function, its location in the coordinate area coded by
the first position code is given by the associated offset
information. (Besides, in this case the size of the
coordinate area coded by the first position code is also
10   given by the associated page size information.) If the
chosen coordinate partial area has another associated
function, it may in this example be placed freely within
the coordinate area coded by the first position code. The
indication then also comprises a location which may be
15   given by a coordinate pair within the coordinate area
coded by the first position code. On the basis of the
indication in step 82, the processor determines a second
matrix which defines the cell values for that part of the
coordinate area coded by the first position code which
20   corresponds to the location of the chosen coordinate
partial area. Alternatively, the second matrix may define
the cell values for the entire coordinate area coded by
the first position code. The second matrix constitutes an
input signal to the next step in the coding. In the
25   following step, the processor 71 determines on the basis
of the second matrix and according to a predetermined
algorithm also a value of a second parameter for each of
the marks, step 83, and stores these calculated values in
the memory. More specifically, the processor determines a
30   third matrix which is of the same size as the first
matrix, the processor assigning to each mark the value
zero or four, where zero indicates a small dot and four a
large dot. The algorithm for calculating the value of the
second parameter can be determined by a person skilled in
35   the art based on the above description and the above-
mentioned WO 01/26032. Finally, the first and the third
matrix are added up by the values of marks, corresponding

to each other, in the first and the third matrix being added up so that a fourth matrix is formed where each element has a value between zero and seven. Each element corresponds to a mark in the position-coding pattern and

5   defines its location and size as follows:

0 = small dot, offset to the right

1 = small dot, offset upwards

2 = small dot, offset to the left

3 = small dot, offset downwards

10   4 = large dot, offset to the right

5 = large dot, offset upwards

6 = large dot, offset to the left

7 = large dot, offset downwards

When the coding is completed, the position-coding

15   pattern can, if desired, be printed by means of the printer 75. The fourth matrix may, for example, be sent to a program generating a PostScript file for direct printing on the printer.

Fig. 12 shows an example of how it is possible to

20   realize the user unit 2 in Fig. 1, which can be used as a decoding device. It comprises a casing 91, which is shaped approximately as a pen. In the short side of the casing there is an opening 92. The short side is intended to abut against or be held a short distance from the

25   surface from which the position-coding pattern is to be recorded.

The casing accommodates essentially an optics part, an electronic circuitry part and a power supply.

The optics part comprises at least one light-

30   emitting diode 93 for illuminating a partial area on the surface with a position-coding pattern and a light sensitive area sensor 94 (corresponding to the sensor S in Fig. 1), for instance a CCD or CMOS sensor, for recording a two-dimensional image of the position-coding

35   pattern on the surface. Optionally, the device may additionally contain an optical system, such as a mirror and/or lens system. The light-emitting diode can be an

infrared light-emitting diode, and the sensor may be sensitive to infrared light.

The power supply for the user unit is obtained from a battery 95 which is mounted in a separate compartment
5   in the casing. It is also conceivable to supply power via a cable from an external power source (not shown).

The electronic circuitry part comprises a processor unit 96 with a processor which is programmed to read images from the sensor and to decode the position-coding
10 pattern in these images, and a working memory and a program memory. The processor can also be programmed to execute certain operations on the basis of the decoded information. The processor can, for example, send infor- mation to a specific address included in the decoded
15 information as a result of its interpreting and process- ing of the decoded information. To this end, there is a description of the second coordinate system's division into coordinate partial areas 9 and the coordinate fields' extent in these coordinate partial areas stored
20 in a storage 901 in the user unit. The description may also, as mentioned above, include information associated with the different coordinate partial areas, such as information about the different functions of the coordinate partial areas, page sizes and offsets.
25   In this embodiment, the user unit further comprises a pen point 97 (corresponding to the pen point T in Fig. 1), by means of which the user can write conventional ink-based writing on a base from which the coding pattern is to be recorded. The pen point 97 can be retractable
30 and extendable so that the user can control whether it is to be used or not. In some applications, the user unit does not need to have a pen point at all.

The ink-based writing is suitably of such a type that it is transparent to infrared light and the marks
35 absorb infrared light. By using a light-emitting diode which emits infrared light, and a sensor which is sensitive to infrared light, the detection of the pattern

takes place without the above-mentioned writing interfering with the pattern.

As indicated in Fig. 12, the pen point 97 is positioned outside the field of view of the sensor. In
5 the plane of the position-coding pattern, the pen point is thus offset in the plane from the projection of the sensor surface on the plane so that the pen point is not positioned within the image recorded by the sensor.

Therefore, software is also stored in the user unit
10 2, making it possible for the user unit to carry out correction for the displacement of the pen point, i.e. to calculate, on the basis of the position-coding pattern read by the sensor, the coordinates, corresponding to the location of the pen point, in the first and the second
15 coordinate system.

The user unit 2 may further comprise buttons 98 by means of which the device is activated and controlled. It also has a transceiver 99 for wireless transmission, for instance using IR light, radio waves or ultrasound, of
20 information to and from the device. The user unit 2 may further comprise a display 900 for showing recorded and/or processed information.

The user unit may be divided into different physical casings, a first casing containing components which are
25 necessary for recording images of the coding pattern and for transmitting these to components which are located in a second casing and which decode the coding pattern in the recorded image or images.

An example of how the coding pattern can be decoded
30 will now be described with reference to Fig. 13.

In a first step 100, the processor unit 96 in the user unit 2 receives a digital representation of the position-coding pattern which the sensor 94 has recorded locally at the end of the user unit. Then the processor
35 unit decodes the first position code by identifying the marks in the digital representation, determining the virtual raster and the location of the marks in relation

to this, and calculating coordinates for a point in the first coordinate system, step 101, on the basis of the location of a predetermined number of the identified marks. A more detailed description of how the position

5 information can be decoded is given in WO 01/26032.

When the first position code has been decoded, the processor unit can determine in step 102 how the cells used for decoding the second position code are located. Once the location of the cells is determined, the proc-

10 essor unit knows which marks belong to the respective cells in the digital representation of the position-coding pattern. The processor unit may then determine the size of the marks in the cells in the digital representation. Since it is given that each cell should contain

15 two small and two large marks or merely four small marks, the processor unit 96 can relatively easily determine which marks are small and which are large by comparing the sizes of the marks with each other. Nevertheless, a more detailed description of how this is done follows

20 below. When the sizes of the marks in the cells in the digital representation have been established, the processor unit 96 determines whether the position-coding pattern in the digital representation contains the second position code, step 103. For this to be the case, there

25 must be at least a predetermined number of cells in which the marks are of different sizes for a cell value to be determined. When the second position code cannot be detected, the coordinates for the point in the first coordinate system are processed as coordinates belonging

30 to an ordinary pen stroke on the surface, step 104.

However, if the second position code can be detected, the processor unit decodes, step 105, the second position code. More specifically, the processor unit determines the cell value of each of a predetermined

35 number of cells, for instance by using a table which is stored in the memory of the user unit. With the aid of the thus determined cell values, the processor unit can

then determine the coordinates for a point in the second
coordinate system according to the same principles as
used in the determination of the coordinates for a point
in the first coordinate system.

5   When the second position code has been decoded, the
processor unit can determine if the pen point of the user
unit is located in a field on the surface, step 106. If
this is not the case, the coordinates decoded from the
first position code are processed in the memory as

10   coordinates belonging to an ordinary pen stroke on the
surface, step 107. On the other hand, if the processor
unit determines that the pen point of the user unit is
located in a field, it identifies which function is
associated with the field, step 108, and performs this

15   function, step 109. The function can, but need not,
involve the coordinates decoded from the first position
code.

        The coordinates that are decoded by means of the
first and second position code are coded by that partial

20   area of the position-coding pattern which is within the
field of view of the sensor. If the sensor is displaced
from the pen point, the pen point has another position
than the sensor and therefore the coordinates decoded by
the user unit do not entirely mirror the position of the

25   pen point. For this reason, the decoding of the position-
coding pattern may comprise a correction for the pen
point displacement. The correction can be carried out in
the manner described in WO 01/71654. It can also be
carried out as follows.

30   When the position-coding pattern on the surface is
imaged by the sensor in the user unit 2, the image may be
deformed owing to defects in the imaging system. More-
over, the position-coding pattern will frequently be
imaged with perspective displacements owing to the user

35   unit being inclined when used and therefore the sensor
surface of the sensor being inclined in relation to the
position-coding pattern. For the locations of the marks

to be determined, the perspective must therefore first be straightened out in the image. This is done by first determining the coordinates in the sensor's coordinate system for each mark identified in the image. Then a
5   transformation to a straightened coordinate system, a so called raster coordinate system, is made. To this end, use is made of a homogeneous transform. More specifically, first a two-dimensional column vector is determined, where each element contains the x and y coordinates
10   (in the sensor's coordinate system) for all marks identified in the image. Each element is then increased by the value 1 and thus contains the triplet x,y,1. Then the column vector from the left is multiplied by a transformation matrix of the size 3x3. The matrix element
15   furthest down to the right in the transformation matrix is one. The other elements are calculated so that the transformation matrix transforms the raster lines imaged in perspective in the sensor image so that they become orthogonal and have integer distances (see also Digital
20   Image Processing, Rafael C. Gonzalez and Richard E. Woods, Addison-Wesley Publishing Company, Inc., 1993, ISBN 0-201-60078-1, in particular pp 61-68). When the column vector is multiplied by the transformation matrix, a new column vector is obtained which in each element has
25   the triplet x,y,z. If x and y are divided by z, the x and y coordinates are obtained for the marks in the raster coordinate system. Even if the pen point (T in Fig. 1, 97 in Fig. 12) is not imaged in the sensor image, it is possible to determine its position in the sensor coord-
30   inate system based on the knowledge of the location of the pen point in relation to the sensor and the rotation of the user unit in relation to the imaged position-coding pattern. The above-mentioned transformation may then also be used to transform the position of the pen
35   point from the sensor's coordinate system to the raster coordinate system.

In the following the decoding of the values of the cells will be described in more detail with reference to Figs 14 and 15. Fig. 14 shows a cell with four dots, where the two uppermost dots are small and the two

5   lowermost large. The dots are designated A-D in the order up to the left, up to the right, down to the left and down to the right. In the decoding of the value of the cell, the sizes of the dots are compared in pairs. The following difference groups are defined, which are also

10   indicated in the Figure:

$d1 = sA-sD$

$d2 = sB-sC$

$x1 = sA-sB$

$x2 = sC-sD$

15   $y1 = sA-sC$

$y2 = sB-sD$

where sA stands for the size of the dot A, sB for the size of the dot B, sC for the size of the dot C and sD for the size of the dot D.

20   Moreover the following probabilities are defined:

P1 = probability that the dots in the group have the same size

P2 = probability that the first dot in the group is larger than the second dot

25   P3 = probability that the second dot in the group is larger than the first dot.

The probabilities P1, P2, P3 can be defined as follows:

30   $P1 = \exp(-(d^2/v))$

If $d < 0$

   P2=0

   P3=1-P1

Else

35   P2=1-P1

   P3=0

where d = the difference in size between the first and
the second dot in the group, the size being measured in
number of pixels in the image of the dot, and P1 + P2 +
P3 = 1. Moreover, v is the variance of the dot sizes.

5   This variance v can be set so that the desired
performance is achieved in decoding. With a great value
of v, it is more probable that two dots in a group are
estimated to be of the same size. The ideal value of v
depends on the quality in the image-processing which
10   determines the size of the dots.

Fig. 15 shows a plot of P1, P2 and P3, where the
variance is set at 2.

The cells can have the cell values 0-4, where 0
means that all dots are small, i.e. that the second
15   position code cannot be detected, and the cell values 1-4
correspond to the bit pairs 0,0; 0,1; 1,0; and 1,1;
according to Fig. 9. The probability of the different
cell values 0-4 is given by the following:

20   0: P1d1 * P1d2 * P1x1 * P1x2 * P1y1 * P1y2
1: P1d1 * P1d2 * P2x1 * P3x2 * P2y1 * P3y2
2: P1d1 * P1d2 * P3x1 * P2x2 * P3y1 * P2y2
3: P2d1 * P2d2 * P1x1 * P1x2 * P2y1 * P2y2
4: P3d1 * P3d2 * P1x1 * P1x2 * P3y1 * P3y2
25   or
0: min(P1d1, P1d2, P1x1, P1x2, P1y1, P1y2)
1: min(P1d1, P1d2, P2x1, P3x2, P2y1, P3y2)
2: min(P1d1, P1d2, P3x1, P2x2, P3y1, P2y2)
3: min(P2d1, P2d2, P1x1, P1x2, P2y1, P2y2)
30   4: min(P3d1, P3d2, P1x1, P1x2, P3y1, P3y2)

Each cell is assigned the cell value which has the
highest probability. More advanced procedures for
selecting cell value on the basis of probability
calculations may also be used.

35   Below follows a specific example of determination of
cell values as described above: Assume that the processor
unit in a cell has identified four marks of the sizes:

sA=6, sB=7, sC=4 and sD=5 pixels. By using the variance v= 2 and min(…) definition for the cell values, the following difference groups are obtained:

d1 = 1

5   d2 = 3

x1 = -1

x2 = -1

y1 = 2

y2 = 2

10   the probabilities:

P1d1 = 0.6065

P2d1 = 0.3935

P3d1 = 0

P1d2 = 0.0111

15   P2d2 = 0.9889

P3d2 = 0

P1x1 = 0.6065

P2x1 = 0

P3x1 = 0.3935

20   P1x2 = 0.6065

P2x2 = 0

P3x2 = 0.3935

P1y1 = 0.1353

P2y1 = 0.8647

25   P3y1 = 0

P1y2 = 0.1353

P2y2 = 0.8647

P3y2 = 0

and the cell value probabilities:

30   0 = 0.0111

1 = 0

2 = 0

3 = 0.3935

4 = 0

35   which give that the cell value is 3.

The positions decoded by means of the first position code and the positions decoded by means of the simul-

taneously recorded second position code should represent
the same movement of the pen over the position-coded
surface. Therefore the decoding can be improved by
matching the positions decoded from the first position
5   code against the positions decoded from the second
position code. Thus, by matching successive positions
decoded from the first and second position codes,
incorrectly decoded positions can be detected. Further-
more, if e.g. the different cell values with associated
10 probability values are stored for successive positions,
incorrectly decoded positions from the second position
code can be detected and/or a most probable sequence of
positions can be selected to constitute the decoded
positions from the second position code. This idea of
15 matching positions from overlaid or superimposed first
and second position codes can be used for all kinds of
overlaid position codes and independently of for what
reason the position codes are overlaid or superimposed.
Alternative Embodiments
20 In the examples above, the second position code is
used for marking fields on a base or surface. In an
alternative embodiment the second position code can be
used for enabling a unit, which receives information
recorded by means of a pen and a position-coding pattern
25 on a base, to re-create the movement of the pen over the
base. This embodiment is described with reference to Fig.
16, which schematically shows a digital template 160 and
a position-coded surface in the form of a paper product
165. The digital template 160 defines a plurality of
30 different partial areas, e.g. a writing area 161, ICR
areas 162, selection areas 163 for selection of different
alternatives and a send area 164. The digital template is
valid for a predetermined part of the first position
code. The predetermined part can be divided into a number
35 of subareas or pattern pages, which all have the same
size and which all have the different partial areas 161-
164 defined by the template 160.

When a user wants to create a paper product 165 with position code, he may cut out different partial areas from the digital template, or rather from one of the different pattern pages for which the digital template is

5   valid, and arrange them in a different mutual arrangement, as suggested by the arrows in Fig 16.

Since the digital template corresponds to a continuous part of the first position code, the first position code will be discontinuous between adjacent

10   fields, e.g. fields 162' and 161' on the paper product. The pen used for recording information from the paper product 165 need not know the relationship between the fields on the paper product. It suffices that it has access to the digital template 160 in order for it to be

15   able to handle the information, i.e. the coordinates, recorded from the paper product 165. However, if the movement of the pen over the base is to be displayed by an external unit, e.g. a PC, to which the coordinates are sent, the PC needs to know the spatial arrangement of the

20   fields on the paper product.

This problem can be solved by overlaying a second continuous position code on the first position code. The PC can then use the second position code for determining how a pen which has recorded coordinates in the non-

25   adjacent coordinate areas by means of the first position code, was moved over the surface when recording the coordinates.

As an alternative to sending the coordinates decoded from both the first and the second position code, the

30   coordinates decoded from the first position code and offset indications can be sent to the external unit.

More particularly, for each pen stroke, the pen first determines a first offset of the pen from the upper left corner of the page. This first offset could be

35   determined by means of the second position code. Then the pen sends the coordinates decoded from the first position code to the external unit, which now know how these

coordinates are related to the upper left corner of the page. As soon as the pen discovers a discontinuity in the first position code which discontinuity has no correspondence in the second position code, it knows that it is passing from one cut-out field to another. As a result it determines a second offset in relation to the upper left corner by means of the second position code and sends the second offset to the external unit, which then knows how the coordinates received after the detection of the discontinuity relates to the upper left corner and thus to the coordinates received before the detection of the discontinuity.

In the examples above, use is furthermore made of a position-coding pattern, in which the first position code is coded by means of the location of the marks and the second position code is coded by means of the size of the marks. Of course, both the first and the second position code can be coded by means of other parameters than those exemplified here. As an alternative, the shape of a mark can be used as a parameter. The marks can, for example, have different values on the basis of whether they are circular, triangular, rectangular, star-shaped, elliptic, hexagonal or of some other detectable shape. In order to be able to detect different shapes in different perspectives and different lighting, it may however be necessary to use a sensor with relatively high resolution. As a further alternative, the color of the mark can be used, so that the value of the mark depends on the color. However, for this purpose, a color sensor is required, or illumination with light of different wavelengths.

In the examples described above, the marks are also in the form of circular dots. It is of course possible to use marks of a different shape, for example, triangular, square, elliptic, rectangular or hexagonal dots.

In the examples described above, all the cells have two large dots and two small dots or four small dots for coding of five different cell values. It is of course

possible to have smaller or larger cells with fewer or more cell values which are coded with other combinations of values of the second parameter.

The principle of using a second position code for marking fields with special functions can also be used for position-coding patterns of essentially different construction. For instance, the position-coding pattern does not need to be floating.

In the examples described above, the first and the second position code are coded with common marks which have a first parameter which codes the first position code and a second parameter which codes the second position code.

It is also conceivable to use common marks which only vary in one parameter. In this case, a predetermined number of marks code a number, which can be expressed with a predetermined number of bits or digits. Of these bits or digits, a first predetermined number is then used to code the first position code, and a second predetermined number to code the second position code.

In the examples above, the same marks in an image are used for determining both a position corresponding to the first position code and a position corresponding to the second position code. However, if more marks are detected in an image recorded by the pen than are strictly needed for decoding a position from the first position code and/or a position from the second position code, different marks in the image may be used for decoding the positions from the first and second position codes, respectively.

Examples of methods for coding and decoding have been described above. The steps of these methods can at least partly be carried out in a different order.

The methods can, as has been made evident, be realized in a coding device and a device for recording of information from a surface, which each have a processor unit and associated computer programs. The methods can

also be realized with some other type of signal
processor, for instance application specific hardware,
such as an ASIC or FPGA or a similar unit, which can be
adjusted so that it will be suited for this specific task
5   and with analog and/or digital circuits or a suitable
combination thereof.

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